IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Rainer HAEBERER et al

Based on PCT/DE 01/02371

For: FUEL INJECTION VALVE FOR INTERNAL COMBUSTION ENGINES

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION

Page 1, Between the title and paragraph [0001] please insert the following:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/02371, filed on June 27, 2001

[0000.6] BACKGROUND OF THE INVENTION

Please replace paragraph [0001] with the following rewritten paragraph:

[0001] Field Of The Invention

Please replace paragraph [0002] with the following rewritten paragraph:

[0002] The invention is based on a fuel injection valve for internal combustion engines, preferably self-igniting internal combustion engines.

Between paragraphs [0002] and [0003] please insert the following:

[0002.4] Description Of The Prior Art

[0002.6] One fuel injection valve or the type with which this invention is concerned is known from International Patent Disclosure WO 96/19661. In this known valve, a blind bore in which a valve member is guided is embodied in a valve body. The valve member is surrounded on its portion toward the combustion chamber by a pressure chamber which can be filled with fuel at high pressure. A conical valve seat is embodied on the bottom face of the blind bore, toward the combustion chamber. Moreover, at least one injection port, which connects the bore to the combustion chamber, is embodied on the bottom face.

Page 2, Please replace paragraph [0004] with the following rewritten paragraph:

[0004] If the valve member is not precisely axially aligned, the inflow of fuel from the pressure chamber at the conical faces of the valve member tip and past the sealing edge to the injection ports is no longer symmetrical. The injection ports, relative to which the valve member is also off its axis, are covered at the onset of the opening stroke motion by the valve member, so that no fuel or only very little fuel can flow to them. Only in the course of the complete opening stroke motion of the valve member are the initially covered injection ports uncovered, and only then can the fuel also flow through these injection ports. The consequence is a reduction in the total injected fuel quantity and thus a power loss to the engine.

Page 3, Please replace paragraph [0006] with the following rewritten paragraph:

[0006] SUMMARY OF THE INVENTION

Please replace paragraph [0007] with the following rewritten paragraph:

[0007] The fuel injection valve of the invention has the advantage over the prior art that in the region of the injection ports, at the second conical face of the valve member tip, a further encompassing annular groove is formed, which at the very outset of the opening stroke motion distributes the fuel, flowing from the pressure chamber to the injection ports, to all the injection ports. If in the opening stroke motion the valve member is off its axis toward one injection port, then some of the fuel flowing to the other injection ports is diverted into a tangential flow through the additional annular groove and thus flows to that injection port. This assures an adequate inflow of fuel to all the injection ports, and even if the valve member is off its axis, a symmetrical injection through all the injection ports is obtained, and the aforementioned disadvantages of uneven injection are averted.

Page 4, Please delete paragraph [0010]:

Please replace paragraph [0011] with the following rewritten paragraph:

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

Please replace paragraph [0012] with the following rewritten paragraph:

[0012] Various exemplary embodiments of the fuel injection valve of the invention are described herein below, with reference to the drawings, in which:

Between paragraphs [0012] and [0013] please insert the following:

[0012.2] Fig. 1 shows a fuel injection valve partly in longitudinal section;

[0012.4] Fig. 2 is an enlarged view of Fig. 1 in the region of the valve seat; and

[0012.6] Figs. 3, 4, 5 and 6 show the same detail as Fig. 2 for further exemplary embodiments.

Page 5, Please replace paragraph [0013] with the following rewritten paragraph:

[0013] DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 7, Please replace paragraph [0019] with the following rewritten paragraph:

[0019] In Fig. 2, the fuel injection valve is shown enlarged in the region of the valve member tip 7 in the closing position of the valve member 5. The valve seat 9 is a conical face with a cone angle γ, which preferably amounts to from 50 to 70°. At the end toward the combustion chamber, the valve seat 9, for production reasons, changes into a bulge 48. At least one injection port 11 is embodied in the valve seat 9 and extends either perpendicularly or at an incline to the valve sealing face 9. If a plurality of injection ports 11 are provided, then they are preferably distributed uniformly over the circumference of the valve body 1, tailored to the engine combustion chamber to be supplied. The injection ports 11 can for instance be located in a common plane radial to the axis of the valve member 5, or distributed over a plurality of radial planes, or be located in a plane that is inclined to the axis of the valve member 5.

Page 12, Please replace paragraph [0028] with the following rewritten paragraph:

[0028] In Fig. 4, a further exemplary embodiment of a fuel injection valve of the invention is shown. The first edge 46 of the additional annular groove 42 is located on the injection ports 11 in the closing position of the valve member 5, so that the conical face located between the annular grooves 35, 42 partly covers the injection ports 11.

Page 13, After paragraph [0030] please insert new paragraph:

[0031] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 14, Line 1, delete "Claims" and insert --"We Claim"--.

IN THE CLAIMS

Please cancel claims 1-12 and add new claims 13-32.

13. In a fuel injection valve for internal combustion engines, having a valve body (1) in which a bore (3) is disposed, on whose end toward the combustion chamber a conical valve seat (9) is embodied in which at least two injection ports (11) are disposed that connect the bore (3) to the combustion chamber, and having a valve member (5), which is guided in the bore (3) and by imposition of pressure by fuel on a pressure face (13) embodied on the valve member (5) is axially movable counter to a closing force aimed at the valve seat (9) and which has a valve member shaft (205), oriented toward the valve seat (9), between which shaft and the wall of the bore (3) a pressure chamber (19) that can be filled with fuel is embodied, which valve member (5), on its end toward the combustion chamber, has a valve member tip (7) on which a first conical face (30) and a second conical face (32), adjoining the first conical face (30) toward the combustion chamber, is embodied, and the cone angle (α) of the first conical face (30) is less, and the cone angle (β) of the second conical face (32) is greater, than the cone angle (γ) of the valve seat (9), and having an annular groove (35), extending all the way around the valve member tip (7), the first groove edge (38) of which is located in a radial plane to the axis of the valve member (5) and on the first conical face (30), and whose second groove edge (39) is located in a radial plane to the axis of the valve member (5) and on the second conical face (32), and the first groove edge (38) of the annular groove (35) is embodied as a sealing edge, which in the closing position of the valve member (5) comes into contact with the valve seat (9) upstream of the fuel flow to the injection ports (11), the improvement comprising an additional annular groove (42) on the second conical face (32) of the valve member tip (7), the additional annular groove (47) at least partly covering the injection ports (11) both in the closing position and in the open position of the valve member (5).

14. The fuel injection valve of claim 13 wherein the cross section of the annular groove (42) is greater than or equal to the cross section of an injection port (11).

15. The fuel injection valve of claim 13 wherein that a first differential angle (δ_1), located between the first conical face (30) and the valve seat (9), is smaller than a second differential angle (δ_2), located between the valve seat (9) and the second conical face (32).

16. The fuel injection valve of claim15 wherein the first differential angle (δ_1) and the second differential angle (δ_2) amount to less than 1.5°.

17. The fuel injection valve of claim 13 wherein the cone angle (γ) of the valve seat (9) amounts to from 55 to 65°, preferably approximately 60°.

18. The fuel injection valve of claim 13 wherein the groove edges (44; 46) of the additional annular groove (42) are located in planes radial to the valve member axis (50) of the valve member (5).

19. The fuel injection valve of claim 13 wherein the conical face adjoining the groove edge (46), remote from the combustion chamber, of the additional annular groove (42) partly covers the injection ports (11) in the closing position of the valve member (5).

20. The fuel injection valve of claim 14 wherein the conical face adjoining the groove edge (46), remote from the combustion chamber, of the additional annular groove (42) partly covers the injection ports (11) in the closing position of the valve member (5).

21. The fuel injection valve of claim 15 wherein the conical face adjoining the groove edge (46), remote from the combustion chamber, of the additional annular groove (42) partly covers the injection ports (11) in the closing position of the valve member (5).

22. The fuel injection valve of claim 16 wherein the conical face adjoining the groove edge (46), remote from the combustion chamber, of the additional annular groove (42) partly covers the injection ports (11) in the closing position of the valve member (5).

23. The fuel injection valve of claim 13 wherein the injection ports (11) are located in a common radial plane relative to the valve member axis (50).

24. The fuel injection valve of claim 13 wherein the groove edges (44; 46) of the additional annular groove (42) and the injection port outlets are in a plane that is inclined to the radial plane of the valve member axis (50).

25. The fuel injection valve of claim 13 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

26. The fuel injection valve of claim 14 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

27. The fuel injection valve of claim 15 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

28. The fuel injection valve of claim 16 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

29. The fuel injection valve of claim 17 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

30. The fuel injection valve of claim 18 further comprising at least one longitudinal groove (55) connecting the two annular grooves on the conical face disposed between the annular groove (35) and the additional annular groove (42) each said at least in longitudinal groove (55) extending along jacket lines of the second conical face (32).

31. The fuel injection valve of claim 25 wherein a plurality of longitudinal grooves (55) are more than one longitudinal groove (55) is embodied on the second conical face (32), said longitudinal grooves being distributed uniformly over the circumference.

32. The fuel injection valve of claim 31 wherein at least one of said longitudinal grooves (55) extends at an incline to the jacket lines of the second conical face (32).

IN THE ABSTRACT

Please substitute the attached rewritten Abstract of the Disclosure with the abstract as originally filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully selected.

Respectfully submitted,

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ABSTRACT OF THE DISCLOSURE

Disclosed is a fuel injection valve including a valve body and a bore, embodied as a blind bore, whose bottom face is oriented toward the combustion chamber, and a conical valve seat having at least one injection port is disposed, is embodied on the bottom face. In the bore, a pistonlike valve member, which is longitudinally displaceable counter to a closing force, is disposed and has a valve member tip, which in the closing position of the valve member comes to rest on the valve seat. A first conical face and a second conical face, disposed toward the combustion chamber toward the first conical face, are embodied on the valve member tip, and the cone angle of the first conical face is smaller than the cone angle of the valve seat, which in turn is smaller than the cone angle of the second conical face. One annular groove is embodied between the first conical face and the second conical face, and an additional encompassing annular groove is disposed on the second conical face and at least partly coincides with the injection ports in the closing position of the valve member, so as to supply all the injection ports uniformly with fuel even if the valve member is off its axis.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, Between the title and paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATIONS

[0000.4] This application is a 35 U.S.C. 371 application of PCT/DE 01/02371, filed on June 27, 2001

[0000.6] BACKGROUND OF THE INVENTION

Paragraph [0001] has been amended as follows:

[0001] ~~Prior Art~~ Field Of The Invention

Paragraph [0002] has been amended as follows:

[0002] The invention is based on a fuel injection valve for internal combustion engines, preferably self-igniting internal combustion engines~~, as generically defined by the preamble to claim 1. One such fuel injection valve is known from International Patent Disclosure WO 96/19661. A blind bore in which a valve member is guided is embodied in a valve body. The valve member is surrounded on its portion toward the combustion chamber by a pressure chamber, which can be filled with fuel at high pressure. A conical valve seat is embodied on the bottom face of the blind bore, toward the combustion chamber. Moreover, at least one injection port, which connects the bore to the combustion chamber, is embodied on the bottom face~~.

Between paragraphs [0002] and [0003]:

[0002.4] Description Of The Prior Art

[0002.6] One ~~such~~ fuel injection valve or the type with which this invention is concerned is known from International Patent Disclosure WO 96/19661. ~~A~~ In this known valve, a blind bore in which a valve member is guided is embodied in a valve body. The valve

member is surrounded on its portion toward the combustion chamber by a pressure chamber~~,~~ which can be filled with fuel at high pressure. A conical valve seat is embodied on the bottom face of the blind bore, toward the combustion chamber. Moreover, at least one injection port, which connects the bore to the combustion chamber, is embodied on the bottom face.

Page 2, Paragraph [0004] has been amended as follows:

[0004] If the valve member ~~comes off its axis~~ is not precisely axially aligned, the inflow of fuel from the pressure chamber at the conical faces of the valve member tip and past the sealing edge to the injection ports is no longer symmetrical. The injection ports, relative to which the valve member is also off its axis, are covered at the onset of the opening stroke motion by the valve member, so that no fuel or only very little fuel can flow to them. Only in the course of the complete opening stroke motion of the valve member are the initially covered injection ports uncovered, and only then can the fuel also flow through these injection ports. The consequence is a reduction in the total injected fuel quantity and thus a power loss to the engine.

Page 3, Paragraph [0006] has been amended as follows:

[0006] ~~Advantages of the Invention~~ SUMMARY OF THE INVENTION

Paragraph [0007] has been amended as follows:

[0007] The fuel injection valve of the invention~~, as defined by the characteristics of the body of claim 1,~~ has the advantage over the prior art that in the region of the injection

ports, at the second conical face of the valve member tip, a further encompassing annular groove is formed, which at the very outset of the opening stroke motion distributes the fuel, flowing from the pressure chamber to the injection ports, to all the injection ports. If in the opening stroke motion the valve member is off its axis toward one injection port, then some of the fuel flowing to the other injection ports is diverted into a tangential flow through the additional annular groove and thus flows to that injection port. This assures an adequate inflow of fuel to all the injection ports, and even if the valve member is off its axis, a symmetrical injection through all the injection ports is obtained, and the aforementioned disadvantages of uneven injection are averted.

Page 4, Deleted paragraph [0010]:

[0010] ~~Further advantages and advantageous features of the subject of the invention can be learned from the drawing, the description of the exemplary embodiment, and the claims.~~

Paragraph [0011] has been amended as follows:

[0011] ~~Drawing~~ BRIEF DESCRIPTION OF THE DRAWINGS

Paragraph [0012] has been amended as follows:

[0012] Various exemplary embodiments of the fuel injection valve of the invention are described herein below, with reference to the drawings, in which: ~~shown in the drawing. Fig. 1 shows a fuel injection valve partly in longitudinal section; Fig. 2 is an enlarged view of Fig. 1 in the region of the valve seat, and Figs. 3, 4, 5 and 6 show the same detail as Fig. 2 for further exemplary embodiments.~~

Between paragraphs [0012] and [0013]:

[0012.2] Fig. 1 shows a fuel injection valve partly in longitudinal section;

[0012.4] Fig. 2 is an enlarged view of Fig. 1 in the region of the valve seat; and

[0012.6] Figs. 3, 4, 5 and 6 show the same detail as Fig. 2 for further exemplary embodiments.

Page 5, Paragraph [0013] has been amended as follows:

[0013] ~~Description of the Exemplary Embodiment~~ DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 7, Paragraph [0019] has been amended as follows:

[0019] In Fig. 2, the fuel injection valve is shown enlarged in the region of the valve member tip 7 in the closing position of the valve member 5. The valve seat 9 is a conical face with a cone angle γ, which preferably amounts to from 50 to 70°. At the end toward the combustion chamber, the valve seat 9, for production reasons, changes into a bulge 48. At least one injection port 11 is embodied in the valve seat 9 and extends either perpendicularly or at an incline to the valve sealing face 9. If a plurality of injection ports 11 are provided, then they are preferably distributed uniformly over the circumference of the valve body 1, tailored to the engine combustion chamber to be supplied. The injection ports 11 can for instance be located in a common plane radial ~~plane~~ to the axis of the valve member 5, or distributed over a plurality of radial planes, or be located in a plane that is inclined to the axis of the valve member 5.

Page 12, Paragraph [0028] has been amended as follows:

[0028] In Fig. 4, a further exemplary embodiment of a fuel injection valve of the invention is shown. The first edge ~~38~~ 46 of the additional annular groove 42 is located on the injection ports 11 in the closing position of the valve member 5, so that the conical face located between the annular grooves 35, 42 partly covers the injection ports 11.

Page 13, After paragraph [0030]:

[0031] The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

Page 18, Abstract

~~Abstract~~ **ABSTRACT OF THE DISCLOSURE**

~~A~~ Disclosed is a fuel injection valve ~~with~~ including a valve body ~~(1)~~ and a bore ~~(3)~~, embodied as a blind bore, whose bottom face is oriented toward the combustion chamber, and a ~~. A~~ conical valve seat ~~(9), in which~~ having at least one injection port ~~(11)~~ is disposed, is embodied on the bottom face. In the bore ~~(3)~~, a pistonlike valve member ~~(5)~~, which is longitudinally displaceable counter to a closing force, is disposed and has a valve member tip ~~(7)~~, which in the closing position of the valve member ~~(5)~~ comes to rest on the valve seat ~~(9)~~. A first conical face ~~(30)~~ and a second conical face ~~(32)~~, disposed toward the combustion chamber toward the first conical face, are embodied on the valve member tip ~~(7)~~, and the cone angle ~~(α)~~ of the first conical face ~~(30)~~ is smaller than the cone angle ~~(γ)~~ of the valve seat ~~(9)~~, which in turn is smaller than the cone angle ~~(β)~~ of the second conical face ~~(32)~~. One annular groove ~~(35)~~ is embodied between the first conical face ~~(30)~~ and the second conical face ~~(32)~~, and an additional encompassing annular groove ~~(42)~~ is disposed on the second conical face ~~(32)~~ and at least partly coincides with the injection ports ~~(11)~~ in the closing position of the valve member ~~(5)~~, so as to supply all the injection ports ~~(11)~~ uniformly with fuel even if the valve member ~~(5)~~ is off its axis ~~(Fig. 2)~~.